CLAIMS

1. A microactuator comprising:

a substrate;

a moving element, which is supported on the substrate in a displaceable position;

a driving section for outputting a drive signal that causes displacement in the moving element;

a converting section, which stores a correlation between the displacement of the moving element and the drive signal;

a displacement sensing section for sensing the displacement of the moving element being supplied with the drive signal; and

a calibrating section for calibrating the correlation stored in the converting section with the drive signal and the output of the displacement sensing section.

2. The microactuator of claim 1, wherein the moving element is an electrostatic moving element including a fixed electrode, which is fixed on the substrate, and a movable electrode, which faces the fixed electrode, and

wherein the displacement sensing section senses the displacement of the moving element by a variation in electrostatic capacitance produced between the fixed electrode and the movable electrode.

3. The microactuator of claim 1 or 2, wherein the driving section outputs, as the drive signal, a low-frequency signal, of which the frequency is approximately equal to, or lower than, the primary resonance frequency of the moving element, and

wherein the displacement sensing section superposes, on the drive signal, a high-frequency signal, of which the frequency is equal to or higher than the primary resonance frequency of the moving element.

4. The microactuator of claim 3, wherein the driving section outputs a substantial DC voltage as the drive signal.

5. The microactuator of claim 4, wherein the DC voltage output by the driving section as the drive signal has multiple

stages, and

wherein the displacement sensing section senses the displacement of the moving element in each of the multiple stages, and

wherein the calibrating section approximates the DC voltage in each said stage and the output of the displacement sensing section with an approximation function of a predetermined form.

6. The microactuator of claim 3, wherein the driving section outputs, as the drive signal, a low-frequency signal having multiple stages of frequencies, and

wherein the displacement sensing section senses the displacement of the moving element in which vibration has been produced, and

wherein the calibrating section calculates the amplitude response or phase response of the moving element by correlating the drive signal and the output of the displacement sensing section with each other.

7. The microactuator of claim 3 or 6, wherein the driving section outputs, as the drive signal, a low-frequency signal, of which the frequency is approximately equal to the primary resonance frequency of the moving element, in multiple stages, and

wherein the displacement sensing section senses the displacement of the moving element in which vibration has been produced in each of the multiple stages, and

wherein the calibrating section extracts the primary resonance frequency of the moving element by correlating the drive signal and the output of the displacement sensing section with each other.

8. The microactuator of one of claims 3 to 7, wherein if the amplitude of the drive signal is defined high, the amplitude of the high-frequency signal, generated by the displacement sensing section, is defined low.

9. The microactuator of one of claims 2 to 8, wherein the movable electrode of the moving element includes a first

conductive portion and a second conductive portion, which are arranged substantially symmetrically to each other with respect to a predetermined axis, and is supported so as to tilt freely around the axis, and

wherein the fixed electrode includes a first electrode, which faces the first conductive portion of the movable electrode with a gap, and a second electrode, which faces the second conductive portion of the movable electrode with a gap, and

wherein the driving section supplies the drive signal to either between the first conductive portion and the first electrode or between the second conductive portion and the second electrode, and

wherein the displacement sensing section applies a first high-frequency signal to the first electrode and a second high-frequency signal, which has the same amplitude as, but an inverse phase to, the first high-frequency signal, to the second electrode, respectively, thereby detecting a voltage at a terminal where the first and second conductive portions are electrically connected together.

10. The microactuator of one of claims 1 to 9, wherein the converting section generates a voltage command value, which is associated with the displacement of the moving element, and

wherein the driving section includes a D/A converter for outputting the drive signal that has been controlled in accordance with the voltage command value, and

wherein the calibrating section calibrates a correlation between the voltage command value and the displacement of the moving element.

11. The microactuator of claim 10, wherein the D/A converter has a nonlinear characteristic and wherein the larger the value of the drive signal, the smaller the increase of the drive signal corresponding to that of the voltage command value.

12. The microactuator of claim 11, wherein the calibrating section approximates a correlation between the voltage command value and the displacement of the moving

element with a linear function.

13. The microactuator of one of claims 1 to 12, wherein the calibrating section is activated when the microactuator is turned on.

14. The microactuator of one of claims 1 to 13, comprising a temperature sensing section, wherein the calibrating section is activated when the temperature sensing section has sensed a temperature variation that is at least equal to a predetermined value.

15. The microactuator of one of claims 1 to 14, comprising an abnormality detecting section for detecting an abnormality in the moving element or the displacement sensing section when the output of the displacement sensing section is beyond a predefined range.

16. The microactuator of claim 15, wherein if the abnormality detecting section has detected any abnormality,

the calibrating section is prohibited from updating the correlation.

17. A microactuator comprising:

a substrate;

a plurality of moving elements, which are supported on the substrate in a displaceable position;

a driving section for outputting a drive signal that causes displacement in the moving elements;

a displacement sensing section for sensing the displacement of the moving elements; and

a switching section for selectively connecting the driving section and/or the displacement sensing section to one of the moving elements after another.

18. The microactuator of claim 17, wherein the switching section senses the displacement of each said moving element while switching time-sequentially objects of the displacement sensing by the displacement sensing section.

19. The microactuator of claim 17 or 18, comprising a closed loop control section for performing a closed loop control on the output of the driving section with the output of the displacement sensing section.

20. The microactuator of claim 19, further comprising an open loop control section for performing an open loop control on the output of the driving section, wherein the microactuator controls the moving elements by switching the closed loop control section and the open loop control section time-sequentially.

21. The microactuator of claim 20, wherein the open loop control section includes a holding section for holding the output of the driving section that is under the control of the closed loop control section.

22. The microactuator of claim 19, wherein the moving elements are provided so as to store charges in accordance with the drive signal, and

wherein the switching section switches the moving elements between a first state, in which the moving elements are connected to the closed loop control section, and a second state, in which the moving elements have impedance that is high enough to store the charges.

23. The microactuator of one of claims 19 to 22, comprising a counter for calculating a value representing the amount of time in which each said moving element is connected to the closed loop control section and a convergence detecting section for detecting the convergence of the closed loop control,

wherein unless the convergence detecting section detects the convergence even when the output of the counter exceeds a predetermined upper limit, the switching section disconnects the moving element from the closed loop control section.

24. The microactuator of claim 23, wherein the value representing the amount of time in which the moving element is connected to the closed loop control section is the number

of times that the closed loop control section performs its loop repeatedly.

25. The microactuator of claim 23, wherein if the output of the counter is less than the upper limit when the switching section switches the connection of the closed loop control section to the next moving element upon the detection of the convergence by the convergence detecting section, the upper limit of the next moving element is changed according to the output of the counter.

26. The microactuator of one of claims 17 to 25, wherein the switching section connects at least two of the moving elements to the displacement sensing section simultaneously.

27. The microactuator of one of claims 3 to 16, wherein a bias voltage, of which the magnitude is approximately equal to or greater than the amplitude of the high-frequency signal, is applied to both the fixed electrode and the movable electrode.

28. The microactuator of claim 1, comprising a switching section, which is provided for an interconnection line that connects the driving section and/or the displacement sensing section to the moving element so as to switch the interconnection line from a connected state into a disconnected state, or vice versa,

wherein the calibrating section corrects a first output of the displacement sensing section, which is obtained with the interconnection line connected, with a second output of the displacement sensing section, which is obtained with the interconnection line disconnected.

29. The microactuator of claim 1, wherein the moving element includes a fixed electrode, which is fixed on the substrate, and a movable electrode, which faces the fixed electrode, and

wherein the movable electrode includes a first conductive portion and a second conductive portion, which are arranged substantially symmetrically to each other with respect to a predetermined axis, and is supported so as to

tilt freely around the axis, and

wherein the fixed electrode includes a first electrode, which faces the first conductive portion of the movable electrode with a gap, and a second electrode, which faces the second conductive portion of the movable electrode with a gap, and

wherein the driving section generates a first drive signal to be applied to the first electrode and a second drive signal, which has a different magnitude from that of the first drive signal and which is applied to the second electrode, and

wherein the displacement sensing section includes: a high-frequency signal generating section for outputting a high-frequency signal, of which the frequency is equal to or higher than a primary resonance frequency of the moving element; a first load impedance component, which is connected to the first electrode at a first terminal; a second load impedance component, which is connected to the second electrode at a second terminal; and a high frequency detecting section, which is connected to the first and second

terminals, the first drive signal on which the high-frequency signal is superposed being applied to the other terminal of the first load impedance component that is opposite to the first terminal, the second drive signal on which the high-frequency signal is superposed being applied to the other terminal of the second load impedance component that is opposite to the second terminal, and

wherein the high frequency detecting section compares the phases and/or the amplitudes of the high-frequency signal between the first and second terminals, thereby sensing the displacement of the moving element.

30. A deformable mirror comprising the microactuator of one of claims 1 to 29,

wherein a light reflective region is defined in at least a portion of the moving element.

31. A system comprising the microactuator of one of claims 1 to 29.

32. A method of driving a microactuator including a moving element, the method comprising the steps of:

outputting a drive signal that causes displacement in the moving element;

storing a correlation between the displacement of the moving element and the drive signal;

sensing the displacement of the moving element being supplied with the drive signal; and

calibrating the correlation with the drive signal and the output of the displacement sensing section.